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Lawrence Livermore National Laboratory

Laser Science & Technology

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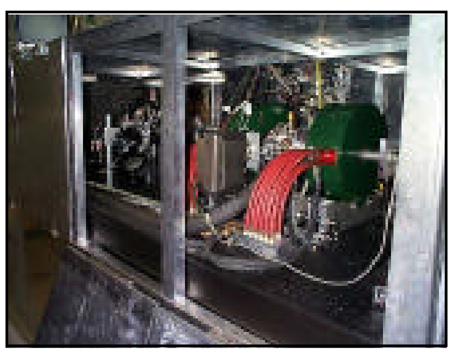
Falcon Laser Making Progress Toward Integration with Linac

With the widespread development of high-peak-power lasers based on chirped pulse amplification, the potential for high-brightness, laser-based, ultrafast sources of x rays now exists. The development of these sources is very attractive since the production of hard x rays ($E > 10$ keV) with a pulse width below 100 fs will make possible unique experiments studying the ultrafast dynamics of matter. Such experiments include watching the motion of atoms in a material or chemical reaction upon laser excitation.

To make such experiments possible, a unique x-ray source is being developed at Lawrence Livermore National Laboratory. This source is based on the integration of the Falcon, a multiterawatt femtosecond laser, with a high-energy (100 MeV) electron linear accelerator (linac). Through Thomson scattering of laser photons off a tightly focused low-emittance beam of relativistic electrons, bursts of tunable hard x rays with pulse duration less than 100 fs will be produced. Doing this entails crossing the femtosecond laser pulse with a 1-ps electron bunch, a task that requires state-of-the-art laser–electron beam synchronization. Progress toward this challenging technical goal has been recently achieved at the Falcon laser (shown below).

The Falcon laser is a Ti:sapphire laser based on chirped pulse amplification. It produces 0.5-J pulses of 35-fs duration at 1 Hz and is currently undergoing an upgrade to the 4 J per pulse level. Transport of these pulses to the B194 linac is under way. A major step toward the integration of Falcon with the linac was recently demonstrated. Photoelectrons produced by seed pulses from the Falcon laser were accelerated in an RF photo-gun (developed by a collaboration with the Engineering Directorate) to 5 MeV (see photo below).

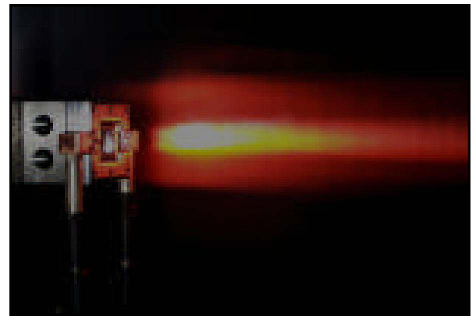
This milestone demonstrates the technical feasibility of the integrated time synchronization and represents a major step toward interacting the Falcon beam with full-energy electron pulses. System integration will continue, with the goal of producing modest-brightness, soft x-ray pulses from the photo-gun electrons by late this spring. Full system integration with the 100-MeV linac, injected with electrons from the photo gun, will commence after this first proof-of-principle demonstration.



Output Irradiance of 1 kW/cm^2 Delivered by Laser Diode Array Cooled by Monolithic Heatsink

For commercial and military applications, there is a need for high-performance laser diode arrays that can be manufactured cost-effectively.

Historically, high-average-power heatsinks have been complex to produce because of the fabrication processes that are needed to provide separate cooling for each laser bar. Alternatively, available monolithic heatsink designs that share a common cooling backplane are simpler, but the thermal performance is not sufficient for many applications.



Our objective is to develop a diode-array that combines the advanced cooling capabilities of discrete heatsinks in a monolithic design. We have recently produced a silicon monolithic microchannel (SiMM) heatsink that can allow up to ten diode bars to be bonded onto a single cooler. The figure above shows a 10-bar diode array mounted on a silicon monolithic microchannel cooler. The thermal impedance of the diode-array package is low ~0.35 K/W even at high bar packing density. Because of the low thermal impedance, we can reliably operate the diode array at outputs up to 50 W/bar cw, or 150 W/bar peak at 25% duty factor with a moderate temperature rise at the diode junction. An output irradiance of 1 kW/cm^2 was demonstrated.

An advantage of the silicon heatsink is that it can be fabricated with lithographic accuracies, such that the diode emission can be collimated to low angular divergence using a single Si-etched lens frame. This packaging approach scales gracefully to large areas and high power, a critical element in diode-pumped solid-state lasers envisioned for the future.

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